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DESCRIPTION

SILENT HOOK-AND-LOOP FASTENER

Technical Field

The present invention relates to a surface fastener and a surface fastener-mounted product equipped with the same surface fastener, and more particularly, to a silent surface fastener which suppresses a noise at the time of peeling.

Background Art

A relatively large noise is generated when an ordinary surface fastener is peeled off. This abnormal noise is generated because a base material vibrates. A noise is always generated when individual engaging elements are peeled, and it is very difficult to completely prevent the noise from occurring.

As regards a method of reducing a noise at the time of peeling of a surface fastener, for example, two US patent specifications have been publicized. According to one of them, US patent No. 4,776,068 (Quiet Touch Fastener Material (1988), patent document 1), propagation of energy into the air is intended to be reduced by adopting a lattice structure in a tape which is a base material of a surface fastener.

The other patent specification, US patent No. 4,884,323

(Quiet Touch Fastener Attachment System (1989), patent document 2) has disclosed a method in which a mounting member is possessed between a surface member and a fabric which is a mounting object, so that the fabric and the surface fastener are separated by the mounting member, or a method in which a noise absorbing material is mounted on a rear face of a surface fastener member to increase the volume of a base material itself, thereby suppressing vibration at the time of peeling.

According to these methods, only end edge portions of the surface fastener are fixed by sewing or the like, and there is no element which fixes the fabric and the surface fastener in the central portion. Thus, these methods are not suitable for attachment of a wide surface fastener. If another noise absorbing material is mounted on the rear face of the fabric, the volume of the base material at a portion on which the surface fastener is mounted increases, so that the appearance quality and tactile feeling drop, thereby providing a feeling of extreme disharmony. Further, there is another problem that a sewing method is complicated to increase the number of manufacturing steps.

Japanese Patent Laid-Open Publication No. 6-103 (patent document 3) has disclosed a surface fastener having a vibration absorbing material on a rear face of a base material. Because the vibration absorbing material is heavy enough to obtain a sufficient effect with this method, the surface fastener has

a drawback that it becomes thick. These technologies pay attention to reduction of a peeling noise. However, there exist a comfortable noise and an uncomfortable noise to acoustic sense of the humans. Just reducing the noise is not a sufficient measure, and it is important not to make feel uncomfortable acoustically.

Further, for example, Japanese Patent Laid-Open Publication No. 2003-153706 (patent document 4) has disclosed a female member of a surface fastener in which a plurality of loops composed of needle punches are possessed on at least one face of a long fiber unwoven fabric composed of a synthetic fiber and the loops are fixed by back coating. When, according to this disclosed female member, a number of loops are formed on at least one face of a long fiber unwoven fabric by needle punch, 5 to 50% of plural single fibers gripped by a needle are cut and a loop is formed at a density of 20 to 120 pieces/cm^2. The unit weight (METSUKE) of the unwoven fabric is set to 30 to 80 g/m^2, the thickness of the unwoven fabric is set to 0.5 to 1.0 mm, an application amount of a back coating agent is set to 10 mass % or less, and a ventilation degree is set to 100 $cc/cm^2/sec$ or more. Consequently, the female member is plastic and secures an appropriate peeling strength while a peeling noise at the time of separation from a male member of the surface fastener is 65 dB or less.

The above-described patent documents 1 to 3 aim at

suppressing a generated noise by a method of lowering a ratio of vibration of the base material transmitted to the air. However, when such a surface fastener is mounted on a mounting object, the vibration of the surface fastener base material is transmitted to the mounting object, so that radiation of a noise from the mounting object is accompanied. Consequently, no sufficient noise suppressing effect can be obtained. Further, if a mounting member or a vibration absorbing material is provided on the back, the entire thickness is increased. Consequently, if such a surface fastener is used for clothing or the like, the fastener becomes bulky, so that texture of a fabric product is lost.

Moreover, after the surface fastener is sewed, vibration at the time of peeling is transmitted to the mounting object equipped with the surface fastener, so that a noise is generated from the mounting object, too. Thus, no noise suppressing effect is often generated even if the generated noise of the surface fastener itself is suppressed.

The patent document 4 aims at suppressing the peeling noise because a resistance generated when a male engaging element looses out of a loop can be reduced by reducing the quantity of fibers constituting loops of the female member of the surface fastener. It can be understood that the peeling noise is suppressed by reducing the resistance when the male engaging element looses out of the loop in the case of general

surface fasteners. However, it cannot be said that just reducing the quantity of fibers constituting the loops as disclosed in this invention does not always lead to reduction of the resistance, and the resistance changes depending on a relation with various factors such as the size of a mating male engaging element, a shape (hook-like, mushroom-like or the like), and the thickness of fibers constituting the loops. Thus, it is not considered that a peeling noise of the above-mentioned level can be obtained unless various factors as well as the above-mentioned factors are added.

The present invention has been achieved to solve such a problem. More specifically, an object of the invention is to develop a surface fastener which remarkably reduces a generated noise at the time of peeling while securing a required peeling strength in the surface fastener itself and which can suppress the generated noise at the time of peeling of a surface fastener mounted product equipped with the same surface fastener.

Disclosure of the Invention

The present invention reduces vibration of a flat base material in a surface fastener as much as possible, thereby suppressing generation of an abnormal noise at the time of peeling of the surface fastener.

According to experiments by the inventors, it has been found that an abnormal noise from a surface fastener is

generated when engagement between a male engaging element and a female engaging element is released in a base material of the engaged surface fastener, that is, when those engaging elements pull each base material strongly at the time of peeling, and then, when the engagement is released, the pulled base materials are restored to their original states instantly. It is considered that at this time, vibration is transmitted through the air like a speaker cone, so that it is transmitted as a noise. The lattice structure disclosed in the patent document 1 corresponds to making holes in the speaker cone, which suppresses the transmission efficiency of vibration to the air.

On the other hand, as a result of considerations by the inventors, it has been made evident that a level of the peeling noise is reduced if the entire engaging force of the surface fastener is reduced by decreasing the quantity of the engaging elements per unit area (hereinafter referred to as element density) (pieces/cm^2) than a conventional one to reduce the tensile strength of the engaging elements at the time of peeling or intensifying the plasticity of at least one of the engaging element and the base material. Further, it has been made evident also that setting the mass per unit volume of the base material (hereinafter referred to as apparent density) to 0.5 (g/cm^3) or less contributes to suppression of a noise. The present invention has made us know that the level of the peeling noise can be reduced to 80 dB by applying these facts

independently or by combination.

However, reduction of the engaging force by reducing the density or strength of the engaging element or reducing the apparent density of the base material itself, or by intensifying the plasticity of the engaging element and/or the base material necessarily leads to lowering of the peeling strength. A product value as a surface fastener is lost unless a required peeling force is secured. Thus, as a result of accumulated considerations by the inventors, it has been found that an amount corresponding to a drop in engaging force between the engaging elements needs to be compensated with another engaging and disengaging means, and at the same time, such an engaging and disengaging means must not generate a peeling noise at the time of peeling. Based on the observation, the present invention has been achieved in the following content.

More specifically, the basic configuration of the present invention exists in a silent surface fastener comprising: a first surface fastener member having a plurality of engaging elements on a surface of a first flat base material; and a second surface fastener member having a plurality of engaging elements on a surface of a second flat base material, the second surface fastener being joined to the first surface fastener member through a plane, being characterized in that at least one of the first and second surface fastener members has noise suppressing means and auxiliary engaging and disengaging means

which engages and disengages from a mating one without generation of a noise at a time of engagement or disengagement, and a level of the generated noise at the time of peeling is 80 dB or less.

At least one of the first and second surface fastener members has a noise suppressing means as described above, and also has an auxiliary engaging and disengaging means capable of engaging and disengaging from a mating surface fastener member without generation of a noise at the time of engagement or disengagement. Accordingly, the level of a noise generated due to disengagement of the engaging elements is suppressed largely by the noise suppressing means when the surface fastener is released, and the amount corresponding to a drop in engaging force between the engaging elements due to suppression of a noise is compensated with the auxiliary engaging and disengaging means which can be released without generation of a noise at the time of engagement or disengagement. The releasing force at this time is set so that a sum of the engaging forces of the engaging elements is equal to a sufficient joining force which secures a peeling force required as the surface fastener.

The noise suppressing means which suppresses the peeling noise between the surface fastener members aims at reducing the entire engaging force by reducing the density (pieces/cm^2) or the engaging strength of the engaging elements, or by

intensifying the plasticity of at least one of the engaging element and the base material, as described above. On the other hand, to compensate for the reduction of the engaging force, there is provided an auxiliary engaging and disengaging means which generates no releasing noise at the time of release and which has a joining force that compensates for reduction in the engaging force.

The material and structure of the first and second surface fastener members of the present invention may be a fiber woven fabric, knitted fabric or unwoven fabric as a flat base material or a synthetic resin flat plate obtained by molding. Examples of the engaging element include an engaging element made of monofilament which is a bold continuous fiber or multifilament, and a synthetic resin engaging element formed integrally by molding on the surface of the flat base material. As the engaging element, an ordinary hook-like shape, a mushroom-like shape, a palm tree-like shape and their modifications may be adopted.

As for the first and second surface fastener members of the present invention, both of them are constructed of fiber products in some case, one of them is all constituted of a fiber product while the other is all constituted of a synthetic resin product in some case, and both of them are constituted of synthetic resin molded articles in other case. In the case where both the first and second surface fastener members are

constituted of fiber products, usually, the engaging elements for the woven fabric and knitted fabric are constituted of monofilament (male engaging element) and/or multifilament (female engaging element), and in the case of the unwoven fabric, a loop (female engaging element) of a composition fiber exposed on the surface is used. The case where both the first and second surface fastener members are molded surface fasteners made of synthetic resin includes a self-engaging surface fastener used for both male and female, in which engaging elements are, for example, hook-like or mushroom-like so that they engage or disengage from each other.

In this case, examples of the fiber include polyester fibers such as polyethylene terephthalate and polybutylene terephthalate; polyamide fibers such as nylon 6, nylon 66, nylon 610, nylon 11, and nylon 12; polyolefin fibers such as polyethylene, polypropylene, and ethylene propylene base polymer; and synthetic fibers such as a vinyl chloride base polymer fiber and an acrylic base fiber.

On the other hand, examples of the synthetic resin include polyester resins such as polyethylene terephthalate and polybutylene terephthalate; polyamide resins such as nylon 6, nylon 66, nylon 610, nylon 11 and nylon 12; polyolefin resins such as polyethylene, polypropylene and an ethylene propylene base polymer; various thermoplastic synthetic resins such as a vinyl chloride base polymer, acrylic base resin, polyamide

elastomer, and polyurethane elastomer.

In the case where the engaging element is a fiber-made male engaging element formed integrally on the surfaces of the flat base materials (11, 22) made of a fiber material, it is important for the noise suppressing means to satisfy at least any one of the following requirements (a) to (c). In this case, the requirements (a) to (c) may be used independently or in combination.

(a) The element density of the male engaging elements is 35 (pieces/cm^2) or less.

(b) The tensile strength of the engaging element is 2.5 to 5.0 (cN/T) and the elastic modulus of the engaging element is 19.0 to 38.0 (cN/T).

(c) The apparent density of the first and second flat base materials and/or the engaging element is 0.5 (g/cm^2).

On the other hand, in the case where the engaging element is a male engaging element made of synthetic resin formed integrally on the surface of the flat base material obtained by molding synthetic resin, it is critically important for the noise suppressing means to satisfy at least any one of the following requirements (d) and (e). In this case, the requirements (d) and (e) may be adopted independently or by combination.

(d) The element density of the male engaging elements is 250 (pieces/cm^2) or less.

(e) The tensile strength of the engaging element is 50 (MPa) or less and the elastic modulus of the engaging element is 1.1 (GPa) or less.

In the case of an engaging element made of a fiber fabric, its column portion is in a column-like shape having a specified section in the longitudinal direction even if its shape is hook-like, mushroom-like or palm tree-like, and there is a limit in reduction of the engaging element density with a weaving/knitting structure or an unwoven fabric structure. Usually, even the density of fiber-made monofilament using the finest monofilament used as the surface fastener is made to have a limit in 330 T. If it is intended to obtain an engaging strength capable of bearing an actual use with the size, the engaging ratio of the engaging elements needs to be increased. As a result, an engaging strength capable of bearing an actual use cannot be obtained even if using a finer monofilament having an engaging density smaller than 36 pieces/cm^2 considered to be the smallest engaging element density of ordinary products. However, as for the reduction of the noise level, the level of noise volume of the surface fastener generated at the time of peeling decreases as the density of the engaging elements is decreased.

Also from the viewpoint of the tensile strength and elastic modulus of the fiber-made engaging element, the level of noise volume generated at the time of peeling of the surface

fastener drops as the values of the tensile strength and elastic modulus decrease. In the case of an engaging element using 330T monofilament which is considered to be the finest of the ones used as the surface fastener, its tensile strength is 5.09 (cN/T) and its elastic modulus is 38.8 (cN/T). Therefore, in order to suppress the noise to a level of noise volume lower than a peeling noise of the surface fastener using fiber-made engaging elements considered conventionally to be the finest, the tensile strength of the engaging element needs to be 5.09 (cN/T) or less, and its elastic modulus needs to be less than 38.8 (cN/T). The tensile strength and the elastic modulus can vary by controlling the draw ratio or cooling speed of the fiber so that it is possible to obtain various values.

In the present invention, in the case of the fiber-made engaging element, preferably, the tensile strength is set to 2.5 to 5.0 (cN/T), and the elastic modulus is set to 19.0 to 38.8 (cN/T). If the tensile strength is less than 2.5 (cN/T), it is so small that the engaging element is easily broken by even a slight peeling force, so that it cannot bear an actual use. In addition, if the tensile strength exceeds 5.0 (cN/T), the level of noise volume at the time of peeling exceeds 80 dB although it is related to the elastic modulus, which is not preferable. On the other hand, if the elastic modulus is less than 19.0 (cN/T), a desired engaging force drops considerably, and even if the aforementioned auxiliary engaging and

disengaging means is used at the same time, a peeling force required as the surface fastener cannot be obtained.

If the apparent density of the first and second flat base materials and/or the engaging element is 0.5 (g/cm^2), the level of noise volume when the surface fastener is released can be lowered largely. Particularly, it is preferable that the apparent density of the base materials of respective fiber-made surface fastener members which are mating is 0.5 g/cm^3 or less, and that each base material has a substantially equal fiber density all over the surface. The flat base material having a substantially equal fiber density refers to a variety of woven/knitted fabrics in which warp/weft densities or the course density and wale density are equal all over the surface of the woven fabric or knitted fabric, or a variety of unwoven fabrics in which the percentage of void of fiber is dispersed substantially equally. Because the apparent density of the base material is 0.5 g/cm^3 or less, at least the base material of one surface fastener may be formed in a multiple woven/knitted structure which is woven or knitted in multiple layers.

One of the noise suppression principle according to the present invention exists in that the vibration transmission capacity of the base material itself is reduced by reducing the weight of the base material per unit volume, i.e., the apparent density to reduce a vibrating area of the base material, thereby

reducing the efficiency of transmission of the vibration to the air, that is, the efficiency of transmission of the vibration to the air is suppressed by reducing the size of a speaker cone. As a specific method of reducing the vibration transmission rate of the base material, it is effective to use a bent structure without linearly forming the weaving/knitting structure yarns. Further, an effect occurs when the density of the base material is reduced, particularly, when the apparent density is dropped to 0.5 g/cm^3 or less.

The vibration of the base material can be considered to be classified to transverse wave and longitudinal wave. The transverse wave is a vibration at right angle to the longitudinal direction of the yarn. This vibration is easily damped due to friction with surrounding yarns or a back coating material. Further, if any damping material etc. is provided, the vibration can be damped further effectively. On the other hand, the longitudinal wave is a wave which vibrates in the longitudinal direction of the yarn. The propagation velocity of this wave is determined by the storage elastic modulus of the yarn, and the damping is determined by the loss elastic modulus of the yarn. Usually, a ratio between the storage elastic modulus and the loss elastic modulus is about 10:1 at a room temperature, and damping under the room temperature is not so large. A method of bending a yarn is effective to damp the longitudinal wave. Part of energy of the longitudinal wave

is converted to the transverse wave by this bending, and the longitudinal wave is damped quickly each time when the yarn is bent. To intensify the damping effect, it is desirable to set a bending angle to 90° or more.

In the case of a structure whose yarn bending is small like a plain weaving structure, vibration is dispersed in a wide range without being damped. On the other hand, in the case of a structure in which a yarn is bent frequently like a knitting structure, vibration is damped due to the bending of the yarn, so that vibration is captured within a small area. However, if the apparent density of the weaving/knitting structure is 0.5 g/cm^3 or less, both the structures produce a large effect.

Particularly, in the case of a bulky yarn, the effect is conceivable. If a bulky base material is formed by using a bulky yarn or twisted yarn, loss at the time of propagation of acoustic vibration increases, so that a range which a noise reaches decreases, thereby inhibiting generation of a noise. An acoustic wave transmitted through the base material is damped also by using a yarn in which fibers composed of a material having a high viscoelastic character, particularly, high tan delta are mixed as the composition yarn of the base material. Consequently, the vibration range is narrowed, thereby inhibiting generation of a noise.

On the other hand, when, according to the present invention, the engaging elements are formed integrally with the

flat base material of synthetic resin, an extremely small engaging element can be molded due to improvement in manufacturing accuracy of a molding die and molding technology. Thus, the shape and dimension of the engaging element are diversified different from the fiber-made engaging element. For example, in terms of the engaging element density, an engaging element having a maximum density of 400 (pieces/cm^2) has been proposed conventionally as well. However, in consideration of an engagement with a mating fiber loop, it is difficult for those fibers to invade into a gap between adjoining engaging elements having the aforementioned engaging element density because of its ordinary single fiber fineness (diameter), and thus, an appropriate engaging strength can be hardly obtained. An actual upper limit of the engaging element density is about at most 300 (pieces/cm^2).

According to the present invention, the engaging element made of synthetic resin cannot be demanded to have an enough engaging strength as a single engaging element because of its special engaging head configuration, and engaging elements capable of securing an appropriate engaging strength when totally considered are preferred to have an engaging element density of 250 (pieces/cm^2) or less. The engaging element having an ordinary shape is preferred to have a density of 20 to 150 (pieces/cm^2), and further preferred to have a density of 20 to 100 (pieces/cm^2).

On the other hand, the tensile strength of the engaging element made of synthetic resin is 34 to 42 MPa for polypropylene, 50 to 84 MPa for nylon base resin, and 7 to 38 MPa for polyethylene. Their elastic modulus are 1.1 to 1.4 GPa, 1.0 to 3.1 Gpa, and 0.4 to 1.0 Gpa, respectively.

According to the present invention, the tensile strength is set to 50 Mpa or less, preferably 17 to 34 MPa. Further, the elastic modulus is set to 1.1 Gpa or less, preferably 0.2 to 1.1 GPa. If the tensile strength exceeds 50 MPa, the level of the peeling noise of the surface fastener exceeds 80 dB although this is related to a mating female engaging element, and if it is less than 17 MPa, the engaging strength drops tremendously, which is incapable of bearing an actual use. If the elastic modulus exceeds 1.1 GPa, the engaging element is so hard that its engaging strength is increased, so that the level of noise volume generated at the time of peeling of the surface fastener becomes so high. In addition, if the elastic modulus is less than 0.2 GPa, the engaging element is too elastic to obtain a required engaging strength. In this case, the engaging element cannot be used for actual purpose even if the auxiliary engaging and disengaging means is provided.

Furthermore, the present invention may include setting of a value of a ratio (A/B) between an area A of a region in which an acoustic spectrum of a peeling noise Fourier-transformed in a range of 100 Hz to 15000 Hz is 100 Hz to 3000

Hz and an area B of a region in which the acoustic spectrum of the peeling noise Fourier-transformed in the range of 100 Hz to 15000 Hz is 3000 Hz to 15000 Hz to 0.4 or more as a noise suppressing means regardless of whether fiber-made or synthetic resin-made. Although this can be said to be a means for reducing an uncomfortable noise rather than the noise suppressing means, this specification handles a regulation about the frequency of the generated noise as the noise suppressing means.

The uncomfortable noise can be suppressed by shifting the acoustic quality of the peeling noise generated by the surface fastener itself to lower a feeling of discomfort and by shifting a peeling noise generated by a product equipped with the surface fastener to lower a feeling of discomfort. The noise generated when the surface fastener is released is a discrete, sharp and quickly damped noise. Generally, such a noise is offensive to the ears. If a high frequency component is removed from such a noise, the acoustic quality changes to a soft noise.

It is recommended to use an acoustic spectrum for comparing the noise. The acoustic spectrum is expressed with its frequency set on the axis of abscissa and its intensity set on the axis of ordinate. The acoustic spectrum is obtained by Fourier transformation. Usually, high-speed Fourier transformation (FFT) is carried out by a computer. The FFT needs data of factorial quantity of two, and the resolution depends on the quantity of data. The lowest frequency which

can be analyzed is determined by a sampling time. Further, the highest frequency is determined by a sampling cycle. Therefore, it is important to indicate an analysis range clearly when discussing the acoustic spectrum. Usually, the axes of abscissa and ordinate of the acoustic spectrum are expressed with logarithm.

According to experiments by the inventors, it has been made evident that, in a frequency range of 100 Hz to 150000 Hz, the quality of the noise can be evaluated by comparing areas around 3000 Hz as a standard. A peeling noise including a number of high frequencies of 3000 Hz or more is offensive to the ears, thereby providing with a feeling of discomfort, and a noise including a small number of high frequencies turns to a soft noise. When a ratio (A/B) between an area A of a region in which the acoustic spectrum of a Fourier transformed peeling noise is 100 Hz to 3000 Hz and an area B of a region in which the acoustic spectrum of the Fourier transformed peeling noise is 3000 Hz to 15000 Hz is less than 0.4, the peeling noise is felt to be offensive to the ear and uncomfortable.

Further, if the maximum component of the acoustic spectrum of the peeling noise Fourier transformed in a range of 100 Hz to 15000 Hz is a frequency lower than 3000 Hz, the peeling noise is not felt to be uncomfortable. Particularly, in the case of a surface fastener having joining faces having a plurality of fiber-made engaging elements on a surface of its

flat base fabric, the ratio (A/B) between the area A of a region in which the acoustic spectrum of a peeling noise Fourier transformed in a range of 100 Hz to 15000 Hz is 100 Hz to 3000 Hz and the area B of a region in which the acoustic spectrum of the peeling noise Fourier transformed in the range of 100 Hz to 15000 Hz is 3000 Hz to 15000 Hz may be 0.4 or more, and the maximum component of the acoustic spectrum of the peeling noise Fourier transformed in a range of 100 Hz to 15000 Hz may be a frequency lower than 3000 Hz. In such a case, the peeling noise is not offensive to the ear or uncomfortable.

Moreover, the hardness of the surface fastener base material affects the acoustic quality as described before. The acoustic quality of a noise generated at the time of peeling can be shifted to a low frequency side by forming the surface fastener base material with a soft base material and providing with voids, so that the uncomfortable noise at the time of peeling can be transformed to a soft noise. If the elastic modulus of the base fabric or engaging element etc. is high, the characteristic frequency is located at a high pitch noise side, and if the elastic modulus is low, the characteristic frequency is shifted to a low frequency side. A method of bending the yarn or reducing the density as described above is effective for softening the base fabric of the surface fastener so as to shift the generated noise to a low pitch noise.

In terms of the fiber-made surface fastener, vibration

can be considered as transverse wave and longitudinal wave separately. The transverse wave is a vibration at right angle to the longitudinal direction of the yarn. This vibration is easily damped by friction with surrounding yarns or a back coating material. Further, it is damped further effectively if a damping material is provided. On the other hand, the longitudinal wave is a wave that vibrates in the longitudinal direction of the yarn. The transmission speed of this wave is determined by the storage elastic modulus of the yarn, and the damping is determined by the loss elastic modulus of the yarn. A ratio between the storage elastic modulus and the loss elastic modulus is about 10:1 at a room temperature, and the damping at the room temperature is not so large. A method of bending the yarn is effective for damping the longitudinal wave. Part of energy of the longitudinal wave is converted to a transverse wave by bending, and the longitudinal wave is damped each time when the yarn is bent.

Further, adjusting the bulkiness of the yarn is also effective. A twisted yarn itself has bulkiness, and the bulkiness of its woven/knitted fabric is increased, so that the apparent density drops, which is preferable. If, in the case of the weaving/knitting structure, part of the composition yarns is woven or knitted in the form of a loop, the apparent density further decreases, so that a noise having a high frequency generated at the time of peeling of the surface

fastener is shifted to the low frequency side effectively. Consequently, an uncomfortable noise is converted to a soft noise.

The present invention compensates a drop in engaging force generated by adoption of the above-described noise suppressing means with a joining force of the auxiliary engaging and disengaging means which can be released without generation of a noise at the time of peeling of the surface fastener, thereby securing a total joining force necessary as the surface fastener. The auxiliary engaging and disengaging means uses a magnetic force, an adhesive force by an adhesive agent, a sucking force by vacuum, a mechanical joining force by firm fitting, and a deformation force by temperature transformation of a shape-memory material composed of a metal or resin material. These may be used independently or by combining some of them.

If a magnetic force is used as the auxiliary engaging and disengaging means, magnetic metal or magnetic powder is incorporated or mixed in part of fibers or yarns constituting each base material of the first and second surface fastener members in the case of, for example, a fiber-made surface fastener, the drop in the engaging force between the engaging elements is compensated by engaging or disengaging the base materials themselves by the magnetic force. Further, a powder magnetic material may be mixed in each engaging element of the first and second surface fasteners. Alternatively, an area in

which the engaging elements are formed and an area in which no engaging elements are formed are provided in regions of the first and second surface fastener members corresponding to each other, and a magnetic body may be disposed in the area in which no engaging elements are formed, respectively. By disposing the magnetic material, the level of noise volume generated when the surface fastener is peeled is reduced, and at the same time, a required peeling force is secured.

The magnetic material is selected appropriately from a widely known ferrite base hard magnetic material, a ferrite base soft magnetic material, a metallic hard magnetic material and a metallic soft magnetic material depending on an application. Usually, the main material of the surface fastener is synthetic resin regardless of whether it is formed as a fiber or molded article. Thus, the magnetic material cannot be used as it is as a material of the composition member of the surface fastener. Usually, a power magnetic material is mixed in thermoplastic synthetic resin, and then, a desired fiber or molded article is obtained by melting and spinning or molding the mixed material. Alternatively, a fine metallic linear material composed of a permanent magnet is coated with synthetic resin and woven or knitted as part of warps/wefts or part of knitting yarns when the base material is woven or knitted. In the case of a molded surface fastener, it is introduced to the base material at the same time when the flat base material is molded.

Preferably, the average particle diameter of the powder-like magnetic material is in a range of 15 to 25 μm in the case of injection molding (extrusion) in order to secure a rupture strength of a molded article, and for monofilament which constitutes a fiber-made male engaging element, is in a range of 1 to 10 μm in order to secure stability of yarn spinning and a required tensile strength. The amount of mixture of the powder-like magnetic material is 5 to 90 wt%, more preferably 20 to 70 wt% with respect to total materials considering moldability, spinnability, various kinds of strengths and magnetic effect. If it is less than 5 wt%, no required magnetic effect (engaging strength) can be obtained as the auxiliary engaging and disengaging means of the surface fastener. If it is over 90 wt%, no stable molding or spinning can be achieved, and the various kinds of strengths are incapable of bearing an actual use. In the case of a magnetic linear material, the line diameter is set to 1.0 mm or less regardless of whether its sectional shape is circular or an irregular shape.

Although the above-described example uses a permanent magnet as the magnetic body, the present invention permits to place an electromagnetic coil in part of the base material of the surface fastener as another example using a magnetic force so as to excite the electromagnetic coil or make it in non-excitation condition, thereby raising or lowering the entire joining force of the surface fastener.

Although a power supply for exciting the electromagnetic coil and a switch for connecting or disconnecting the power supply can be attached directly to the surface fastener member, they may also be attached to a mounting object of the surface fastener, such as clothing, diaper, and gloves. A magnetic body is attached to a corresponding portion of the base material of the surface fastener member to a mating surface fastener member to which the electromagnetic coil is to be attached, or the electromagnetic coil is similarly attached thereto.

As a preferable example of attaching the electromagnetic coil, a molded surface fastener may be integrated with the base material at the same time when the base material is molded such that metal linear material formed preliminarily into a coil is buried directly in the flat base material. In the case of the fiber-made surface fastener, a synthetic resin linear material in which the coil-like linear material is buried is attached to and integrated with the base material by bonding, fusing or weaving at the same time when the base material is woven along an area of the surface of the fiber-made base material in which no engaging elements are formed. In any case, both ends of the coil-like linear material are connected to a power supply.

In the case of using an adhesive force of the adhesive agent as the auxiliary engaging and disengaging means, an engaging element formation area and a non-formation area are defined on a surface of the base material corresponding to the

first and second surface fastener members, and projections having substantially the same height as the engaging element are formed in the non-formation area so as to form an adhesive agent layer on the surface. The existence of the adhesive agent layer compensates for drop in the joining force of the surface fastener due to the noise suppressing structure by making use of the adhesive force between the adhesive agent layers. At the same time, the surface fasteners can be released from each other without increasing the level of the peeling noise. Examples of the adhesive agent include three types, water soluble type, solvent type and hot melt type. More specifically, acrylic base, rubber base, urethane base, silicone base and the like are available.

When the sucking force by vacuum is used as the auxiliary engaging and disengaging means, for example, sucking disks are formed instead of the adhesive agent layer on the surface of one surface fastener member, and a flat smooth surface which is sucked by the sucking discs is formed instead of the adhesive agent layer at a portion corresponding to the mating surface fastener member. A drop in the joining force of the surface fastener due to the noise suppressing structure is compensated by using a sucking force between the sucking discs and the flat smooth surface like when the auxiliary engaging and disengaging means is adopted. At the same time, the surface fastener can be released without increase of the level of the peeling noise

at the time of peeling of the surface fastener. Examples of a material of members which constitutes the sucking discs and flat surface include various resins such as acrylic base, rubber base, urethane base, and silicone base as well as the adhesive agent. As for the size of the sucking disc, ones of micro (μm) order and nano (nm) order have been developed recently, and naturally, the sucking discs of these sizes may be adopted.

If the mechanical joining force by firm fitting is used as the auxiliary engaging and disengaging means, an engaging element formation area and a non-formation area are defined at a portion corresponding to the surface of the flat base material of the first and second surface fasteners, and a plurality of projections, for example, formed in a pyramid shape with a head which are fitted to each other are provided in the non-formation area. The joining force by firm fitting compensates for shortage of the joining force of the engaging elements without an increase in the peeling noise generated when the surface fastener is released.

Further, the joining strength of the surface fastener can be improved without increasing the peeling noise by making use of a force generated when the shape-memory material transforms depending on changes in temperature. Therefore, as described above, the shape-memory material may be used as the auxiliary engaging and disengaging means of the silent surface fastener. Although the shape-memory material includes iron base memory

alloy and the like as well as Ti-Ni base alloy and Cu-Zn-Al base alloy, Ti-Ni base alloy is often used as the shape-memory alloy for actual use. Although a shape-memory resin and fiber having the same character as the shape-memory alloy have been developed, their applications are limited because their changes in hardness depending on changes in temperature are small. Examples of the material of the shape-memory resin and fiber include polyurethane base, styrene-butadiene base, transpolyisoprene base, and polynorbornene base.

The shape-memory material has a character that after it is deformed at a temperature below transformation temperature, it is restored to its original shape before transformation when the temperature rises to the transformation temperature or more. The hardness drops so that the character becomes mild when the temperature drops below the transformation temperature. Then, no abnormal noise is generated when it is restored to the original shape. If this character is used for part of the engaging elements of the silent surface fastener of the present invention, a noise of a level equal to or higher than the noise reduced by the noise suppressing means at the time of peeling is not generated by executing appropriate temperature control at the time of joining or peeling of the surface fastener. Further, an engaging strength necessary for joining can be secured.

That is, when the hook-like engaging elements are engaged

in an atmosphere not higher than the transformation temperature, they are engaged with mating engaging elements easily because the engaging elements composed of the shape-memory material are mild and deformable, but the engaging force is very small. However, if the temperature is raised to the transformation temperature or more, the engaging elements are restored to the original hook shape and the hardness is restored to the original one, and thus, the joining force is increased. If the surface fastener is placed under an ambient temperature below the transformation temperature when it is released, the hardness drops and the character softens, so that the engaging elements become very easy to deform and the releasing strength drops. Consequently, the engaging element itself composed of the shape-memory material is released from a mating engaging element easily without generation of a noise.

The above-described auxiliary engaging and disengaging means may be used independently or by combination of some of them.

As understood from the above description, the silent surface fastener has the above-described noise suppressing means and auxiliary engaging and disengaging means. Thus, even if a joining strength necessary as the surface fastener is not secured due to adoption of the noise suppressing means, not only the joining strength necessary as the surface fastener is compensated by the auxiliary engaging and disengaging means,

but also only a peeling noise suppressed by the noise suppressing means is generated at the time of peeling of the surface fastener because the auxiliary engaging and disengaging means blocks a noise from being generated when the surface fastener is released. Therefore, only a quiet noise of at most 80 dB is generated.

The most preferable embodiment of the present invention exists in a silent surface fastener comprising: a first surface fastener member having a plurality of engaging elements formed integrally on a surface of a first flat base material made of a fiber material; and a second surface fastener member having a plurality of engaging elements formed integrally on a surface of a second flat base material made of a fiber material, the second surface fastener member being joined to the first surface fastener member through a plane, being characterized in that at least one of the first surface fastener members has a noise suppressing means having a low engaging element density and an auxiliary engaging and disengaging means having magnetism which joins itself to a mating one without generation of a noise at the time of engagement or disengagement, and a level of the peeling noise is 80 dB or less.

In this case, the engaging element density is preferably 35 (pieces/cm^2) or less. Further, the auxiliary engaging and disengaging means using magnetism is preferred to be a magnetic linear material having magnetism. The flat base material has

a foundation structure constituted of a weaving structure or a knitting structure composed of warps and wefts, and the warps and/or wefts include a magnetic linear material having magnetism. At this time, the magnetic linear material is preferred to be a metal linear material having magnetism or a synthetic fiber mixed with magnetic powder. Further preferably, the flat base materials are magnetically joined to each other by attracting the foundation structures including the magnetic linear material having magnetism. Moreover, the engaging element is preferred to include engaging elements having magnetism.

Brief Description of the Drawings

FIG. 1 is an exploded view schematically showing an example of a silent surface fastener in which all first and second surface fastener members are constituted of fiber materials.

FIG. 2 is an exploded view schematically showing another example of the silent surface fastener in which all first and second surface fastener members are constituted of fiber materials.

FIG. 3 is an exploded view schematically showing a still another example of the silent surface fastener in which all first and second surface fastener members are constituted of fiber materials.

FIG. 4 is an exploded view schematically showing an example in which a first surface fastener member is a molded article made of synthetic resin while a second surface fastener member is a fiber product.

FIG. 5 is an exploded view schematically showing an example of a silent surface fastener in which all first and second surface fastener members are constituted of synthetic resin materials.

FIG. 6 is a partial side view showing a joining state of the fastener.

FIG. 7 is a partial perspective view schematically showing an example of arrangement of an engaging element formation area and non-formation area of the first and second surface fastener members.

FIG. 8 is a partial perspective view schematically showing another example of arrangement.

FIG. 9 is a partial perspective schematically showing a still another example of arrangement.

FIG. 10 is an explanatory view showing a waveform of a peeling noise generated when the surface fastener is peeled off.

FIG. 11 is an enlarged explanatory view showing part thereof.

FIG. 12 is an explanatory view by comparing the peeling noises depending on the kind of base material.

FIG. 13 is an explanatory view schematically showing a

test about the bending strength of the surface fastener.

FIG. 14 is an explanatory view showing the relation between the bending strength of the surface fastener and the peeling noise.

FIG. 15 is an explanatory view showing the relation between the bending strength of the surface fastener and the high frequency component ratio of the peeling noise.

FIG. 16 is a partial perspective view showing a first embodiment of a silent surface fastener of the present invention adopting an auxiliary engaging and disengaging means.

FIG. 17 is a sectional view showing a separation state of the surface fastener.

FIG. 18 is a sectional view showing a joining state of the surface fastener.

FIG. 19 is a partial perspective view schematically showing a first surface fastener member in which a magnetic linear material is woven integrally into a base material fabric.

FIG. 20 is a perspective view schematically showing a second surface fastener member in which a magnetic linear material is woven integrally into a base material fabric.

FIG. 21 is a partial sectional view showing a state in which the silent surface fastener of the second embodiment is separated.

FIG. 22 is a sectional view partially showing a joining state of the silent surface fastener.

FIG. 23 is a partial perspective view showing a molded surface fastener member to be applied to a third embodiment of the silent surface fastener of the present invention.

FIG. 24 is a sectional view partially showing a state in which the fastener member and the second fastener member are separated.

FIG. 25 is a sectional view partially showing a joining state of the surface fastener.

FIG. 26 is a perspective view partially showing a modification of the molded surface fastener member.

FIG. 27 is sectional view partially showing a joining state between the molded surface fastener member and the second surface fastener member.

FIG. 28 is a perspective view partially showing a fourth embodiment of the surface fastener member of the present invention having a first arrangement example of projections of magnetic bodies.

FIG. 29 is a perspective view partially showing a second arrangement example thereof.

FIG. 30 is a perspective view partially showing a first arrangement example of projections of magnetic bodies.

FIG. 31 is a perspective view partially showing a second arrangement example thereof.

FIG. 32 is a sectional view partially showing a state in which the surface fastener having an auxiliary engaging and

disengaging means of the fourth embodiment is separated.

FIG. 33 is a sectional view partially showing a joining state of the surface fastener.

FIG. 34 is a sectional view partially showing a silent surface fastener according to a fifth embodiment of the present invention using electromagnetism as an auxiliary engaging and disengaging means.

FIG. 35 is a sectional view partially showing its modification.

FIG. 36 is a sectional view partially showing a separation state of a silent surface fastener according to a sixth embodiment of the present invention using an adhesive agent as an auxiliary engaging and disengaging means.

FIG. 37 is a sectional view partially showing a joining state of the surface fastener.

FIG. 38 is a sectional view partially showing a separation state of a silent surface fastener according to its modification.

FIG. 39 is a sectional view partially showing a joining state of the surface fastener.

FIG. 40 is a sectional view partially showing a separation state of a silent surface fastener according to a seventh embodiment of the present invention using a mechanical engaging and disengaging means as an auxiliary engaging and disengaging means.

FIG. 41 is a sectional view partially showing a joining state of the surface fastener.

FIG. 42 is a partially exploded view of the surface fastener.

FIG. 43 is a sectional view partially showing a separation state of a silent surface fastener according to an eighth embodiment of the present invention using sucking discs as an auxiliary engaging and disengaging means.

FIG. 44 is a sectional view partially showing a joining state of the surface fastener.

FIG. 45 is a sectional view partially showing a separation state of a silent surface fastener according to a ninth embodiment of the present invention using a shape-memory material as an auxiliary engaging and disengaging means.

FIG. 46 is a sectional view partially showing a joining state of the surface fastener.

FIG. 47 is an explanatory view partially showing its modification.

FIG. 48 is a sectional view of a silent surface fastener using a magnetic force and an adhesive force in combination as an auxiliary engaging and disengaging means.

FIG. 49 is a sectional view of a silent surface fastener using a magnetic force and a fitting force in combination as an auxiliary engaging and disengaging means.

FIG. 50 is a sectional view of a silent surface fastener

using a magnetic force and a transformation force of a shape-memory material in combination as an auxiliary engaging and disengaging means.

FIG. 51 is a sectional view of a silent surface fastener using a magnetic force, an adhesive force and a fitting force in combination as an auxiliary engaging and disengaging means.

Best Mode for Carrying Out the Invention

Hereinafter, preferred embodiments of the present invention will be described specifically based on indicated examples. Note that in the following description, like reference numerals are used for components (surface fastener 1, first and second surface fastener members 10, 20, flat base materials 11, 21) having a common function.

As a typical surface fastener 1 which can be applied to the present invention, there is a surface fastener constituted of first and second fiber-made surface fastener members 10, 20 in which, as shown in FIG. 1, male and/or female engaging elements 12a, 22a are woven or knitted in at the same time when fiber-made flat base materials 11, 21 are woven or knitted in. In this case, hook-like male engaging elements 12a composed of monofilament are formed on the surface of the base material of a woven or knitted fabric of the first surface fastener member 10, and loop-like female engaging elements 22a composed of monofilament or multifilament are formed on the surface of the

base material of a woven or knitted fabric of the second surface fastener member 20.

As another surface fastener 1, there is a self-engaging type surface fastener in which, as shown in FIG. 2, all fastener members are composed of fiber, and hook-like male engaging elements 12a and loop-like female engaging elements 22a are mixed on the base material surfaces of first and second surface fastener members 10, 20 while any one of them is capable of engaging with or disengaging from itself. The shape of the male engaging element 12a of this fiber-made surface fastener is not limited to the hook-like shape, and may be mushroom-like or a modification thereof as shown in FIG. 3. This mushroom-like engaging element 12a is formed by cutting the vertex of loop of monofilament woven or knitted in the form of a loop into a woven fabric or knitted fabric and by melting its tip with heat. Further, the second surface fastener member 20 shown in FIG. 3 is constituted of an unwoven fabric. In this case, the loop-like female engaging elements 22a are formed on a surface of the unwoven fabric by pulling out part of composition fibers of the unwoven fabric.

The surface fastener 1 of the present invention includes a first surface fastener shown in FIGS. 1 and 2, in which in a first surface fastener member 10, a flat base material 11 made of synthetic resin and hook-like or mushroom-like male engaging elements 12b erected from the base material 11 integrally or

male engaging elements 12b having a variety of shapes (not shown) are molded integrally. The synthetic resin-made surface fastener 1 includes a surface fastener 1 in which both first and second surface fastener members 10, 20 have mushroom-like engaging elements 11b, 21b having the same shape on one surface of flat base materials 11, 21 such that they are capable of joining to/separating from each other, as shown in, for example, FIGS. 3 and 6.

In the following description, in the first and second surface fastener members 10, 20, a formation area A for the engaging elements 12, 22 and a non-formation area B have two configurations. That is, in one configuration, an area in which the engaging elements 12, 22 are formed on one surface of the flat base material 11, 22 and an area in which no engaging elements are formed are arranged alternately in line as shown in FIGS. 7 and 8, and in the other configuration, an area in which the engaging elements 12, 22 are formed is surrounded by an area in which they are not formed so that the area in which the engaging elements 12, 22 are defined in the form of a lattice, as shown in FIG. 9.

The characteristic configuration of the present invention exists in adopting the noise suppressing means in at least one of the first and second surface fastener members 10, 20 of a variety of surface fasteners 1 as described above, and also in adopting an auxiliary engaging and disengaging means

capable of engaging with or disengaging from a mating one without generating a noise at the time of engaging and disengaging in order to compensate an amount of drop in engaging strength of the surface fastener which is generated by adopting the noise suppressing means, so that the level of the peeling noise of the surface fastener 1 is suppressed to 80 dB or less by using these means at the same time.

In the present invention, the noise suppressing means is different between a fiber-made surface fastener and a synthetic resin-made surface fastener.

In the surface fastener 1 in which all the engaging elements 12, 22 of the first and second surface fastener members 10, 20 are composed of fibers, and the engaging elements 12, 22 composed of monofilament and/or multifilament fibers are formed integrally on the surfaces of the flat base materials 11, 21 composed of a woven fabric, knitted fabric or unwoven fabric, the noise suppressing means needs to satisfy at least any of the following requirements (a) to (c):

(a) the element density of the male engaging element (12a, 12b) is 35 (pieces/cm^2) or less;

(b) the tensile strength of the engaging element (12a, 12b) is 2.5 to 5.0 (cN/T), and its elastic modulus is 19.0 to 38.0 (cN/T); and

(c) the apparent density of the first and second flat base materials (11, 21) and/or the engaging element (12, 22) is 0.5

(g/cm^3).

On the other hand, in the integrated molded surface fastener having the male engaging element 12b formed integrally on the surface of the flat base material 11, 21 in which the engaging element 12, 22 is obtained by molding synthetic resin, the noise suppressing means needs to satisfy at least any of the following requirements (d) and (e):

(d) the element density of the male engaging element 12b is less than 250 (pieces/cm^2); and

(e) the tensile strength of the engaging element 12b is 50 (MPa) or less, and its elastic modulus is 1.1 (GPa) or less.

The shape of the fiber-made male engaging element includes a hook-like shape, a mushroom-like shape and their modified shapes as described above, and the column portion of the engaging element 12, 22 erected from the base material 11, 21 has a specified sectional shape along the longitudinal direction thereof. Further, a hook-like or mushroom-like engaging head extending horizontally from a column-like portion is provided at the vertex of the column-like portion. Usually, in the fiber-made surface fastener, a fiber-like monofilament using the finest monofilament used as the surface fastener is limited to 330T. If it is intended to obtain an engaging strength capable of bearing practical use with the size, the engaging ratio needs to be increased by increasing the quantity (engaging element density) of the engaging elements per unit

area. The smallest engaging element density of ordinary products is considered to be 36 pieces/cm^2 which is larger than 35 pieces/cm^2 which is an upper limit of the requirement (a) of the present invention. If an engaging element density smaller than this is set and finer monofilament is used at the same time, an engaging strength capable of bearing the practical use cannot be obtained. However, from viewpoints of suppressing a noise, the level of noise volume of the surface fastener generated at the time of peeling decreases as the engaging element density decreases.

Speaking of the surface fasteners shown in FIGS. 1 to 6, those shown in FIGS. 1, 2 and 4 have the same density which is usually set smaller than the engaging element density of the male/female engaging elements 12a, 22a disposed on the first and second surface fastener members 10, 20. In the first and second surface fastener members 10, 20 shown in FIGS. 3 and 5, the element density of the male engaging element 12a is set extremely smaller than the element density of the female engaging element 22a.

In terms of the tensile strength and elastic modulus of the fiber-made engaging elements 12a, 22a as the requirement (b) for suppressing a noise of the present invention, the level of noise volume generated at the time of peeling the surface fastener drops as these values decrease. In the case of an engaging element using monofilament of 330T considered to be

the finest conventionally used as the surface fastener, the tensile strength is 5.09 (cN/T) and the elastic modulus is 38.8 (cN/T). Therefore, in order to suppress the level of noise volume below the peeling noise of the surface fastener using the fiber-made engaging elements 12a, 22a considered to be the finest conventionally, the tensile strength of each engaging element 12a, 22a needs to be less than 5.09 (cN/T) and its elastic modulus needs to be less than 38.8 (cN/T).

According to this embodiment, in the case of the fiber-made engaging element 12a, 22a, the tensile strength is set to 2.5 to 5.0 (cN/T) and the elastic modulus is set to 19.0 to 38.0 (cN/T). If the tensile strength is less than 2.5 (cN/T), the engaging element is cut out easily due to slight peeling strength because its tensile strength is too small, so that it is incapable of bearing a practical use. Further, if the tensile strength exceeds 5.0 (cN/T), the level of noise volume generated at the time of peeling exceeds 80 dB although this is related to the elastic modulus, and it is not preferable. On the other hand, if the elastic modulus is less than 19.0 (cN/T), the desired engaging strength drops considerably, so that a required peeling force as the surface fastener cannot be obtained even if the auxiliary engaging and disengaging means is used at the same time.

The tensile strength and elastic modulus can be adjusted to desired values by controlling the draw ratio and cooling rate

of the fiber (monofilament or single fiber). Further, the plasticity of the fiber-made engaging elements 12a, 22a of the present invention is controlled by selecting its material. For example, in the case of a polyamide base fiber, the plasticity is lost in order of nylon 6, nylon 66, nylon 610 and nylon 11. A polypropylene fiber is harder than a nylon fiber.

If the apparent density of the first and second flat base materials which is the requirement (c) for suppressing a noise of the present invention is 0.5 g/cm^3 or less, the level of noise volume generated at the time of peeling the surface fastener can be reduced largely. Preferably, the apparent density of each base material of each fiber-made surface fastener member, which is joined to each other, is set to 0.5 g/cm^3 or less, and each base material has a substantially uniform fiber density on its entire surface. The flat base material possessing a substantially uniform fiber density refers to a variety of woven/knitted fabrics whose warp/weft density or course density and wale density are uniform on the entire surface of the woven fabric or knitted fabric, or a variety of unwoven fabrics whose fiber void ratio is dispersed substantially uniformly. Since the apparent density of the base material is set to 0.5 g/cm^3 or less, a multiple woven/knitted structure may be provided, in which the base material of at least one surface fastener member is woven or knitted in multiple layers.

One of the noise suppressing principles of the present

invention exists in reducing the area of the base material which vibrates to reduce the efficiency of propagation of vibration to the air by reducing the weight of the base material per unit volume, that is, by reducing the apparent density to reduce the vibration propagation capacity of the base material itself, namely, suppressing the efficiency of propagation of vibration to the air by reducing the size of a speaker cone. As a specific method of reducing the vibration propagation rate of the base material, a method in which the yarn of the weaving/knitting structure is constructed into a bent structure but not a linear structure is effective. In addition, an effect appears if the density of the base material is set low, and particularly the apparent density is set 0.5 g/cm^3 or less.

The vibration of the base material can be considered as transverse wave and longitudinal wave separately. The transverse wave is a vibration at right angle to the longitudinal direction of a yarn. This vibration is damped easily by friction with a surrounding yarn and a back coating material. Further, if any damping material for damping vibration is provided, it can be damped further effectively. On the other hand, the longitudinal wave is a wave which vibrates in the longitudinal direction of the yarn. The propagation velocity of this wave is determined by the storage elastic modulus of the yarn, and the damping is determined by the loss elastic modulus. Usually, a ratio between the storage elastic

modulus and the loss elastic modulus is about 10:1 at a room temperature, and damping under the room temperature is not so large. A method of bending the yarn is effective to damp the longitudinal wave. Part of energy of the longitudinal wave is converted to the transverse wave by this bending, and the longitudinal wave is damped quickly each time when the yarn is bent. To intensify the damping effect, it is desirable to set a bending angle to 90° or more.

In the case of a structure whose yarn bending is small like a plain weaving structure, vibration is dispersed in a wide range without being damped. On the other hand, in the case of a structure in which the yarn is bent frequently like a knitting structure, vibration is damped due to the bending of the yarn, so that vibration is captured within a small area. However, if the apparent specific gravity of the weaving/knitting structure is 0.5 g/cm^3 or less, both the structures produce a large effect.

Particularly, in the case of a bulky yarn, the effect is remarkable. If a bulky base material is formed using a bulky yarn or twisted yarn, loss at the time of propagation of acoustic vibration increases, so that a range which a noise reaches decreases, thereby inhibiting generation of a noise. An acoustic wave transmitted through the base material is damped by using a yarn in which fibers composed of a material having a high viscoelasticity, particularly high tan delta are mixed

as the composition yarn of the base material, so that the vibration range is narrowed, thereby inhibiting generation of a noise.

Table 1 shows a difference in noise volume generated at the time of peeling with respect to the apparent density of the flat base material of the fiber-made surface fastener. The "noise volume level" in the table indicates a result of measurement of a level of a noise generated at the time of peeling of the surface fastener with a microphone installed 65 mm apart from the surface fastener. As the base material structure of specimens, a plain woven product having an ordinary tight weaving pattern (I), a warp knitted product having wale density (pieces/cm) and course density (pieces/cm) shown in Table 1, and a plain woven tape having a warp/weft yarn density (piece/cm) shown in Table 1 (II) were used. The apparent density of the plain woven product (I) was 0.55 (g/cm^3), the apparent density of the warp knitted product was 0.45 (g/cm^3), and the apparent density of the plain woven product (II) was 0.50 (g/cm^3).

The wale density mentioned here refers to the quantity of wales per unit length (1 cm) in the course direction, and the course density refers to the quantity of courses per unit length (1 cm) in the wale direction. In addition, the warp yarn density refers to the quantity of warps per unit length (1 cm) in the width direction of the woven fabric, and the weft yarn

density refers to the quantity of wefts per unit length (1 cm) in the longitudinal direction of the woven fabric or the quantity of placed wefts.

[Table 1]

Base material structure	Material	Organization, warp/weft, wale/course density	Apparent density (g/cm^3)	Sound level (dB)
Plain woven fabric (I)	Nylon 6	Warp: 60 (pieces/cm) Weft: 20 (pieces/cm)	0.55	94
Warp knitted product	Nylon 6	Wale: 13 (piece/cm) Course: 10 (piece/cm)	0.45	73
Plain woven product (II)	Nylon 6	Warp: 30 (pieces/cm) Weft: 15 (pieces/cm)	0.50	74

As evident from Table 1, it is understood that in a base material composed of the ordinary plain woven product (I), the noise volume is 94 (dB), that is, the noise volume is by far larger than that of a product having the ordinary knit density or the plain woven product (II) having a low density. This indicates that when using a woven fabric as a base material of the surface fastener, decreasing the weaving density inhibits generation of an abnormal noise at the time of peeling, and further, using the knitted fabric generally inhibits generation of a noise. In the case of the knitted product, large bending of the composition yarn is a cause for inhibiting generation of an abnormal noise at the time of peeling. Therefore, effects by the apparent density and bending of the yarn appear by adopting the weaving structure as the base material, thereby

lowering the generated noise.

According to other in-house experiments by the inventors, it is made evident that if, when using a knitted product as a base material, the number (quantity) of repetitions of wales per unit length is assumed to be NW and the number (quantity) of repetitions of courses per unit length is assumed to be NC/cm, the peeling noise can be lowered effectively when the NW + NC is 5.9 or more and 29.0 or less as a result of a number of experiments.

If the woven fabric is used as the base material, the above-mentioned condition can be satisfied in such a manner that as the weaving density, the weft density is set to 18.0 pieces/cm or less, the warp density is set to 37.5 pieces/cm or less, the size of the weft is set to 140 to 300 deniers, the size of the warp is set to 140 to 300 deniers, and the loop yarn which is the composition yarn of an engaging element is set to 450 deniers. It is also effective to lower the density by adjusting the bulkiness of the composition yarn, and it is permissible to use the twisted yarn. The twisted yarn itself has a bulkiness, so that a woven/knitted fabric becomes bulky, thereby lowering its density.

Also when an unwoven fabric is adopted as the flat base material of the present invention, the apparent density is set to 0.50 (g/cm^3) or less by adjusting its unit weight (Metsuke) or the amount of a binder. In the case of the unwoven fabric,

the peeling noise is not generated so much because its composition fibers behave independently. Further, adjusting the apparent density of the base material to 0.50 (g/cm^3) or less can be achieved with a multiple woven fabric which is laminated integrally with a binding yarn besides adjusting the weaving/knitting density as described above.

According to the experiment by the inventors, in a combination of male/female surface fastener members 10, 20 whose apparent densities are both over 0.5 g/cm^3, the noise level generated at the time of peeling is over 93 dB, which is a large noise very offensive to the ears. On the other hand, when the apparent density of one surface fastener member 10 of the male/female surface fastener members 10, 20 is set to 0.5 g/cm^3 or less while the apparent density of the other surface fastener member 20 is set to more than 0.5 g/cm^3, the combination of the surface fastener members 10, 20 provides a noise level of 86 dB at lowest. In contrast, when the surface fastener members 10, 20 whose apparent densities are both 5.0 g/cm^3 or less are combined, the level of a noise generated at the time of peeling drops largely to 74 dB, which is an extremely low noise not offensive to the ears.

In the case where the engaging element is a product made of synthetic resin according to this embodiment, the aforementioned noise suppressing requirement (d) will be considered. Such a product has an extremely small and special

engagement head, and a single engaging element can hardly secure a sufficient engaging strength. If it is intended to secure the sufficient engaging strength entirely, the engaging element density is preferred to be 250 pieces/cm^2 or less, particularly, in the range of 20 to 150 pieces/cm^2 in the case of an engaging element having an ordinary shape and size although the engaging element density can be adjusted to more than 250 pieces/cm^2. If it is intended to lower the volume of the noise generated at the time of peeling and to secure an engaging strength capable of bearing a practical use, the engaging element density needs to be 20 to 100 pieces/cm^2.

As for this engaging element density, as shown in FIGS. 1, 2 and 4, any engaging element density of the first and second surface fastener members 10, 20 may be within the above-mentioned range or only one of the engaging element densities of the first and second surface fastener members 10, 20 may be within that range regardless of whether fiber-made or synthetic resin-made.

On the other hand, the tensile strength of the engaging element made of synthetic resin which is the above-described noise suppressing requirement (e) is 34 to 42 MPa for polypropylene, 50 to 84 MPa for nylon base resin, and 7 to 38 MPa for polyethylene. Their elastic moduli are 1.1 to 1.4 GPa, 1.0 to 3.0 GPa and 0.4 to 1.0 Gpa, respectively.

According to the present invention, the tensile strength

is set to 50 Mpa or less, preferably 17 to 34 MPa. Also, the elastic modulus is set to 1.1 Gpa or less, preferably 0.2 to 1.1 GPa. To keep this tensile strength at 50 Mpa or less, it is preferable to use polyethylene, and even polypropylene base or nylon base is capable of securing a desired strength by changing the composition. Further, increase in strength and elastic modulus is suppressed by cooling rapidly at the time of molding as well.

If the tensile strength exceeds 50 MPa, the level of the peeling noise of the surface fastener becomes likely to exceed 80 dB although this is related to a mating female engaging element, and if it is less than 17 MPa, the engaging strength drops tremendously, which is capable of bearing an actual use. If the elastic modulus exceeds 1.1 GPa, the engaging element becomes hard and its engaging strength is increased, so that the level of noise volume generated at the time of peeling of the surface fastener is increased. In addition, if the elastic modulus is less than 0.2 GPa, the engaging element is too mild to obtain a required engaging strength. In this case, the engaging element is difficult to use for actual purpose even if the auxiliary engaging and disengaging means is provided.

Further, as one of the noise suppressing means regardless of whether fiber-made or synthetic resin-made, the present invention may include setting of a ratio (S1/S2) between an area S1 of a region in which an acoustic spectrum of a peeling noise

Fourier-transformed in a range of 100 Hz to 15000 Hz is 100 Hz to 3000 Hz and an area S2 of a region in which the acoustic spectrum of the peeling noise Fourier-transformed in the range of 100 Hz to 15000 Hz is 3000 Hz to 15000 Hz to 0.4 or more. Although this can be said to be a means for reducing an uncomfortable noise rather than a noise suppressing means, this specification handles a regulation about the frequency of the generated noise as a noise suppressing means.

The noise generated when the surface fastener is peeled is constituted of a waveform shown in FIG. 10. As understood from the figure, the noise generated at this time is discrete, sharp and damped quickly. FIG. 11 shows a noise in enlargement. As understood from the figure, a single peeling noise is a noise having a high frequency, and damped instantaneously, that is, in only 0.1 second. Typically, such a noise is offensive to the ears. If the high frequency component is removed from these noises, the acoustic quality changes so that it changes to soft noise.

FIG. 12 shows a result of measurement of the peeling noise about a specimen shown in Table 2. For the measurement at this time, a microphone was installed 65 mm apart form a fiber-made surface fastener so as to measure a noise generated at the time of peeling. Of the base fabric structures shown in the table, an ordinary product (woven fabric) is a woven fabric similar to plain weaving. An ordinary product (raised fabric) in the

table is a raised woven fabric. On the other hand, the knitted fabric is constituted of a warp knitting structure, and its apparent density is low, so that composition yarns are bent largely due to the knitting structure. When the knitting structure is adopted, the effects of the apparent density and bending of the yarn are reflected synergistically to shift the generated noise largely to a low-pitch noise side.

When an area obtained by integration of components in which the frequency of a noise generated when the surface fastener is peeled is 3000 Hz or less is assumed to be S1 and an area obtained by integration of components in which the frequency is 3000 Hz or more is assumed to be S2, the value of a ratio S1/S2 is called high frequency component ratio. If this high frequency component ratio is 0.4 or more, the noise is not felt as an uncomfortable noise. The high frequency component ratio of each specimen shown in FIG. 12 was 0.164 for the ordinary woven product, 0.204 for the raised woven product, and 1.075 for the knitted product. The maximum component of the acoustic spectrum was 5330 Hz for the ordinary product (woven fabric), 3070 Hz for the ordinary product (raised fabric), and 420 Hz for the knitted product. In the case of the knitted product, its peeling noise sounded as a lower pitch noise and less uncomfortable than other specimens.

[Table 2]

Base fabric structure	Material	Apparent density (g/cm^3)
Ordinary product (woven fabric)	N6	0.55
Ordinary product (raised fabric)	N6	0.55
Knitted product	N6	0.45

According to the present invention, the generated noise is shifted securely to a low frequency side by lowering the density of the base fabric of the surface fastener to soften the base fabric and then lowering the elastic modulus of the base fabric to lower vibration propagation of the high frequency component. As a method of lowering the vibration propagation of a high pitch noise of the base fabric, it is effective to adopt a structure bent as largely as possible without linearly placing yarns constituting the base fabric. Lowering the density of the base fabric, particularly, setting the apparent density to 0.5 g/cm^3 or less is further effective.

Vibration is divided to transverse wave and longitudinal wave, and a method of bending the yarn is effective for damping the longitudinal wave. Part of energy of the longitudinal wave is converted to transverse wave by bending, so that the longitudinal wave is damped quickly each time when the yarn is bent。 To raise this damping effect, the bending angle of the yarn is desired to be 90° or more. In the case of a weaving

structure in which the bending of the yarn is small like the plain woven fabric, vibration is not damped but dispersed widely. On the other hand, in the case of a structure in which the yarn is bent largely like the knitting structure, vibration is damped by the bending of the yarn, so that the vibration stays within a small range.

Particularly, the effect is high when the yarn is bulky. The damping effect is also high when the apparent density of the weaving/knitting structure is 0.5 g/cm^3 or less. If the elastic modulus is high, the characteristic frequency is located on a high pitch noise side, and if the elastic modulus is low, the characteristic frequency is shifted to a low frequency side. As for the base fabric of the surface fastener as well, a high pitch noise is generated if the base fabric is hard, and a low pitch noise is generated if the base fabric is soft. A method of bending the yarn or reducing the density as described above is effective for softening the base fabric of the surface fastener, thereby shifting the generated noise effectively to the low pitch noise side.

Hardness of the base fabric of the surface fastener member can be obtained as a force necessary for bending by means of a pure bending test machine KES-F2 manufactured by KES Kato Tech Co., Ltd. The KES-F2 is actuated as shown in FIG. 13. A fixed chuck 100 and a movable chuck 200 are disposed at a predetermined interval, and a specimen sandwiched by the fixed chuck 100 and

the movable chuck 200 is bent as the movable chuck 200 moves on an orbit having a specified curvature. That is, the movable chuck 200 moves while swinging its neck to maintain a predetermined curvature. The minimum curvature of the specimen measurable at this time is 4 mm. According to such a method, the plasticity of the base fabric is evaluated by obtaining a moment applied to the fixed chuck 100 when the curvature is 4.0 mm. A bending strength of the specimen was obtained with the bending angle as 180°. Data width was converted by 25 mm, and the bending strength per 25 mm was compared.

As regards male and female surface fastener members, their engaging elements were shaved, and the bending strength of the base fabric was measured according to the above-described method. As the bending strength, a sum of measured values of the base fabrics of the male and female surface members was obtained. A generated noise was measured with a noise level meter placed at a distance 65 mm from the specimen. As for a result, the generated noise was intensified as the bending strength increased as shown in FIG. 14. The sum of the bending strengths of ordinary surface fastener members was 46 gf·cm/2.5 cm, and a noise generated at the time of peeling was 95 dB. On the contrary, if the sum of the bending of the base fabric was set to 19 gf·cm/2.5 cm, the generated noise dropped to 75 dB. From such a relation, it is evident that the sum of the bending

of the base fabric is sufficient if it is 36 gf·cm/2.5 cm when obtaining 10 dB dropped point capable of differentiating sound types clearly.

Although the main peak of a spectrum obtained by Fourier transformation of a noise generated at the time of peeling was about 3670 Hz when the bending strength was 46 gf·cm/2.5 cm, it was shifted to a low temperature side up to 775 Hz and dropped when the bending strength was 19 gf·cm/2.5 cm. FIG. 15 indicates that although the high frequency component ratio (A/B) is 0.29 under 46 gf·cm/2.5 cm, it is 0.67 under 19 gf·cm/2.5 cm. From the figure, it may be considered that the relation between the bending strength and the high frequency component ratio is linear.

When this high frequency component ratio is 0.4, the bending strength is 36 gf·cm/2.5 cm. It is evident that if the high frequency component ratio specified by the present invention is 0.4 or more, that is, the bending strength is 36 gf·cm/2.5 cm or less, any uncomfortable noise is prevented from being generated when the surface fastener is peeled. Further, as understood from FIG. 13, if the bending strength is 36 gf·cm/2.5 cm or less, the volume of the peeling noise drops by 10 dB or more compared to that of the ordinal product so that it can be felt that the generated noise is decreased.

By bending yarns to provide a gap between them, high frequency components are damped quickly and only low frequency

components are left. Thus, high frequencies in the center are shifted to the low frequency side. Further, such a base fabric is entirely soft, and its characteristic vibration is shifted largely to the low frequency side because its elastic modulus is low.

The above-described noise suppressing means can reduce the level of noise volume generated when the surface fastener 1 is peeled to 80 dB or less by adopting the respective noise suppressing requirements (a) to (e) and the above-mentioned requirement about the frequency independently or appropriately in combination. However, if it is intended to adopt such a noise suppressing means, the joining strength of the surface fastener 1, in other words, the peeling strength necessarily drops too much, and thus, it is difficult to secure a strength demanded as the surface fastener if any other measure is not taken.

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Thus, the present invention includes an auxiliary engaging and disengaging means in order to compensate the joining strength of the surface fastener 1 as well as the noise suppressing means. This auxiliary engaging and disengaging means has a sufficient engaging strength for compensating an amount corresponding to drop of the joining strength of the surface fastener 1 accompanying an adoption of the noise suppressing means when the engaging and disengaging means are used in an engagement state. In addition, when the surface fastener 1 is peeled, a noise by separation of the engaging and disengaging means itself is not generated.

A typical embodiment of the silent surface fastener of the present invention which adopts the auxiliary engaging and disengaging means will be described specifically with reference to the accompanying drawings. FIGS. 16 to 35 show embodiments using a magnetic force as an auxiliary engaging and disengaging means 30.

FIG. 16 shows a surface fastener 1 whose first and second surface fastener members 10, 20 are entirely constituted of fibers. In the figure, the surface fastener 1 is drawn such that a magnetic linear material 31 is bolder and exposed on a surface on which an engaging elements 12 (22) of a flat base material 11 (12) composed of a woven or knitted fabric are formed. However, in reality, as shown in FIGS. 17 to 22, 24 and 25, the magnetic linear material 31 is a linear material which is

sufficiently fine for being woven or knitted in the flat base material 11 (21) together with other wefts as part of weft, or for being buried in the flat base material 11 (21) of synthetic resin.

According to the first embodiment shown in FIGS. 16 to 18, the magnetic linear material 31 is woven into a non-formation area B in which no engaging elements 12a, 22a are formed, the area B existing in each of the flat base materials 11, 21 of the first and second surface fastener members 10, 20. In this case, no special noise suppressing engaging and disengaging means is adopted for the hook-like male engaging element constituted of monofilament and the loop-like female engaging element 22a constituted of multifilament. Examples of the magnetic linear material 31 include a metal linear material composed of a permanent magnet that is produced by making magnetic metal into a linear material directly and processing it with magnetism, and a resin linear material produced by mixing monofilament of a synthetic resin material with powder having magnetism. The respective magnetic linear materials 31 which magnetically attract each other is permitted to have magnetism or no magnetism. If both of them have magnetism, they need to be supplied with magnetism with opposite polarities. The same thing can be said for embodiments described below. In the meantime, in the case of the metal linear material, its peripheral face is preferred to be coated

with resin from viewpoints of strength and appearance.

FIGS. 19 and 20 show typical structure examples of fiber-made surface fastener members 10, 20 having the above-described magnetic linear material 31. The invention is not limited to the structures shown in these figures. In FIGS. 19 and 20, intervals among respective threads are shown in enlargement in an easy-to-understand manner. However, in reality, the threads are more close to each other, and do not have relative size shown in the figures.

FIG. 19 shows a case where the first surface fastener member 10 has a woven structure. As understood from the figure, the basic structure of the first surface fastener member 10 is of a plain weaving structure. In this case, two yarns are used as a single weft 2, and as the warp, five ordinary warps 3 and four magnetic linear materials 31 are arranged alternately. Of the ordinary three warps 3, one warp 3a is composed of monofilament for forming the engaging element 12a. When the warp 3a strides over the weft 2, it strides obliquely over two warps 3 at the same time, submerges below a next weft 2, and then, strides obliquely back over a next weft 2 with two warps 3, and this operation is repeated. This warp 3a forms a loop when striding obliquely over the weft 2 and the warp 3. This loop is cut partially in the following cutting step, so that it is formed into a hook-like male engaging element 12a.

On the other hand, the second surface fastener member 20

shown in FIG. 20 has a warp knitting structure. Its knitting structure is a combination of three structures of a chain knitting structure of 0-0/1-1, a tricot knitting structure of 0-0/2-2, and a warp in-laid knitting of 0-1/1-0. In this case, a chain knitting yarn 4 and a tricot knitting yarn 5 are ordinary multifilament yarns, and a warp in-laid knitting yarn is the magnetic linear material 31. Here, a needle loop is knitted into between adjoining wales such that it is entangled in a zigzag form. A needle loop connecting the adjoining wales is formed such that it is exposed on the surface in the form of a loop. This loop-like portion is separated to single fibers by buffing or the like in the following step, and turns to a female engaging element 22a. In this indicated example, the magnetic linear materials 31 exist along all the wales.

When the surface fastener 1 of the first embodiment is joined, as shown in FIG. 18, the male engaging element 12a of the first surface fastener member 10 and the female engaging element 22a of the second surface fastener member 20 engage each other, and the magnetic linear materials 31, 31 woven into corresponding portions of the flat base materials 11, 21 magnetically attract each other, so that their base materials join each other. When this surface fastener 1 is separated from its joining state, the engaging elements 12a, 22a which engage each other disengage from each other with a slight generation of a noise while the magnetic linear materials 31 which are the

other engaging and disengaging means disengage from each other without generation of a noise. Therefore, when the surface fastener is peeled, only a noise accompanying disengagement between the engaging elements 12a and 22a adopting the noise suppressing means is generated.

According to a second embodiment shown in FIGS. 21 and 22, a first surface fastener member 10 has the same configuration as that of the first embodiment, and a second surface fastener member 20 has loop-like female engaging elements 22a composed of multifilament on an entire single side of its flat base material 21. Magnetic powder such as metal is mixed in this female engaging element 22a. The amount of the power mixed is determined appropriately in a range of 5 to 90 wt% in consideration of the magnetic effect and fiber spinning performance.

Now, if the first surface fastener member 10 and the second surface fastener member 20 are joined through a plane, the male engaging element 12a and the female engaging element 22a engage each other in the same way as an engagement of the ordinary engaging elements. At the same time, the magnetic linear material 31 woven into the base material 11 of the first surface fastener member 10 attracts the corresponding loop-like female engaging element 22a with magnetism and joins it. When the surface fastener 1 in the engagement state is peeled, the engagement by magnetic attraction between the magnetic

linear material 31 and the loop-like female engaging element with magnetism is released without generation of any noise although the engagement between the ordinary engaging elements is released with a slight noise. Thus, only a noise having an extremely low noise level of 80 dB or less as compared with the ordinary surface fastener is generated at the time of peeling.

FIGS. 23 to 25 show a third embodiment of the surface fastener 1 of the present invention. A first surface fastener member 10 is so constructed that hook-like engaging elements 12b are formed integrally from a synthetic resin material with a flat base material 11 while a second surface fastener member 20 has the same configuration as that of the first embodiment. Here, an ordinary resin material is used as the base material 11 of the first surface fastener member 10, and magnetic powder is mixed in its engaging element 12b. The size of the engaging element 12b at this time is the same as that of the engaging element of the ordinary molded surface fastener, and its element density is set to a value extremely small, i.e., 80 pieces/cm^3.

According to this embodiment, the flat base material 11 of the first surface fastener member 10 and the engaging elements 12 are made of different resin materials. Therefore, if an injection molding method is employed upon manufacturing, although not shown, a base material molding injection machine and an engaging element molding injection machine are prepared, and an ordinary resin material is supplied to the base material

molding injection machine and kneaded and melted. An ordinary resin material and magnetic powder are supplied to the engaging element molding injection machine and kneaded and melted. Each of the melted resins is injected to each runner through sprue for base material molding and engaging element molding, and two-color components can be formed at the same time. Of course, continuous formation can be carried out also by extrusion. In this case, before a base material molding resin is extruded to the peripheral face of a rotation drum, engaging elements mixed with magnetic powder are formed by extrusion to a plurality of engaging element molding cavities formed on the peripheral face of the drum. Thereafter, the flat base material may be continuously molded from an ordinary melted resin material extruded to the peripheral face of the drum integrally such that it is fused with the proximal portions of the engaging elements.

In the silent surface fastener 1 of this embodiment constituted of the first surface fastener member 10 molded integrally of synthetic resin in this way and the second surface fastener member 20 entirely composed of fibers, the male engaging elements 12b mixed with magnetic powder, of the first surface fastener member 10 engage the loop-like female engaging elements 22a composed of multifilament, of the second surface fastener member 20 at the time of joining, and at the same time, the engaging elements 12b and the magnetic linear materials 31 woven into the flat base material 21 of the second surface

fastener member 20 attract each other and join each other. In this case, although both the magnetic powder and the magnetic linear materials 31 may have magnetism having different polarities, only one of them may be provided with magnetism.

When the first and second surface fastener members 10, 20 of the surface fastener 1 in the joining state are peeled from each other, a noise generated at the time of separating the engaging elements 12b, 22a is lowered by reducing the density of the engaging element as a noise suppressing means to an extremely smaller value than usual, and at the same time, the joining strength is compensated for by magnetic attachment, so that the peeling noise of the first and second surface fastener members 10, 20 is suppressed to 80 dB or less, and a required peeling strength secured.

Although the male engaging element 12b shown in FIG. 23 is provided with a simple hook-like shape and magnetic powder is mixed entirely, for example, a hook-like engaging element 12b having a complicated shape as shown in FIG. 26 may be formed by mixing magnetic powder in part thereof. The male engaging element 12b shown in the figure comprises: a hook-like engaging element main body 12b-1; a first rib 12b-2 formed in the shape of a mountain having the same height as that of the engaging element main body 12b-1 on a right or left side face perpendicular to the extension direction of a hook-like head portion; a second rib 12b-3 formed in the shape of a mountain

having a height 1/3 that of the first rib 12b-2; and a third rib 12b-4 having the same shape as that of the second rib 12b-3 and disposed on an outer side face of the first rib 12b-2. Then, the first rib 12b-2 having the same height as that of the engaging element main body 12b-1 contains magnetic powder.

When the first surface fastener member 10 in which the hook-like engaging elements 12b having such a shape are formed integrally on the base material 11 and the second surface fastener member 20 shown in FIG. 24 are joined each other, the high first rib 12b-2 of the male engaging element 12b of the first surface fastener member 10 is attached to the magnetic linear material 31 of the second surface fastener member 20 by magnetic attraction, and at the same time, engages a hook portion of the element main body 12b-1 of the first surface fastener member 10 in a region in which the female engaging elements 22a of the second surface fastener member 20 are formed. In this example, a joining force of the first and second surface fasteners mostly depends on the magnetic force as shown in FIG. 27. However, by changing the height of the female engaging elements 22a, part thereof is caught by hooks of the element main body 12b-1 of the first surface fastener member 10, so that a joining force between a hook and a loop can be provided, thereby intensifying joining strength between the first and second surface fastener members 10, 20.

FIGS. 28 to 31 show a fourth embodiment of the silent

surface fastener 1 of the present invention. According to this embodiment, block pieces 33 and projections 34 are provided in a formation area A and/or a non-formation area B for the engaging elements 12, 22 formed on the base materials 11, 21 of the first and second surface fastener members 10, 20. This block piece and projections are formed of synthetic resin. Preferably, they are formed of a soft synthetic resin material such as polyethylene. The first and second surface fastener members 10, 20 are provided with magnetism by mixing magnetic powder directly in the block piece 33 and projection 34, or as shown in FIGS, 32 and 33 by integrating a magnetic piece 35 on the surface of the block piece 33 or projection 34 by bonding, fusion or coating. In the meantime, the height of the block piece 33 or the projection 34 from the flat base material surface is set equal to or slightly lower than the height of peripheral engaging elements 12, 22.

As shown in FIGS. 28 and 29, a plurality of projections 34 are formed such that they intersect or are arranged in parallel on the surface on which the engaging elements 12, 22 of the surface fastener member 10, 20 having a grid-like engaging element formation area A are formed. In examples shown in FIGS. 30 and 31, a plurality of block pieces 33 are disposed on the same surface of the base material 11, 21 dispersedly at a predetermined interval. The intervals of arrangement of the plurality of block pieces 33 and the projections 34 are

determined by a relation with the noise suppressing means. The shape of the block piece 33 may be determined arbitrarily, and the examples shown in FIGS. 30 and 31 use a rectangular plate-like block piece 33a and a circular block piece 33b.

When providing the block pieces 33 or the projections 34 on the fiber-made flat base materials 11, 21, they can be formed integrally by molding directly on the surface of the respective surface fastener members 10, 20, on which the engaging elements 12, 22 are formed, regardless of whether that area is a formation area or non-formation area for the engaging element 12 and/or the engaging element 22. According to its manufacturing method, although not shown, for example, respective surface fastener members 10, 20 having no block piece 33 or projection 34 are placed on the bottom face of a lower die having a space capable of accommodating the first and second surface fastener members 10, 20. Thereafter, the lower die is closed with an upper die having a plurality of cavities for molding the block piece 33 or the projection 34 in part of the surface of the surface fastener members 10, 20.

At this time, it is desired to leave a space which surrounds part of plural engaging elements 12, 22 formed on the surface of the respective surface fastener members 10, 20 inside the upper and lower dies. When there is no fear that the engaging element 12, 22 may be deformed depending on a die temperature at the time of molding, the some engaging elements

12, 22 to be left may be pressed against the bottom face of the lower die by the surrounding portion of the cavities of the upper die.

On the other hand, when the engaging elements 12b, 22b are molded integrally on the surface of the base materials 11, 21 made of synthetic resin, the block piece 33 or the projection 34 may be molded integrally at the same time even by injection molding or extrusion molding at the time of molding.

FIG. 34 shows a fifth embodiment of the silent surface fastener 1 of the present invention. According to this embodiment, a first projection 34 made of synthetic resin, as shown in FIG. 32, is provided protrudedly in an area of the fiber-made base material 11 of the first surface fastener member 10, in which no hook-like engaging elements composed of monofilament are formed. A coil 36 made of a metal magnetic linear material is buried in the projection 34. Both ends of the coil 36 are connected to a power supply 37 such as a battery through a switch (not shown).

On the other hand, a second projection 38 made of synthetic resin is provided protrudedly in an area of a surface of the fiber-made flat base material 21 of the second surface fastener member 20, the area corresponding to the projection 34 of the first surface fastener member 10. A plurality of loop-like engaging elements 22a are formed between these projections 38 so as to form the engaging element formation area

A. Magnetic powder is mixed in the projection 38.

When the engaging elements 12, 22 of the first and second surface fastener members 10, 20 are pressed against each other, the engaging elements 12, 22 engage each other, so that both the members 10, 20 join each other. The engaging element density of the first and second surface fastener members 10, 20 is set smaller than the ordinary one, and the apparent density of the base materials 11, 21 is set 0.5 g/cm^3 or less. Accordingly, a joining force of both the members 10, 20 is smaller than that of the ordinary surface fastener. If the aforementioned switch is turned on, uni-directional current flows through the coil so as to generate lines of magnetic force, so that the first projection 34 attracts the second projection 38 mixed with magnetic material, and the both firmly join each other.

Because no current flows to the coil when the switch is turned off in order to release joining between the first and second surface fastener members 10, 20, line of magnetic force disappears, and attachment between the first and second projections 34, 38 by magnetic attraction is released. As a consequence, the joining of the first and second surface fastener members 10, 20 can be released quietly with a level of the peeling noise of 80 dB or less suppressed by the noise suppressing means.

Although according to this embodiment, the power supply

37 is turned on/off when the first and second surface fastener members 10, 20 are joined or separated, the power supply 37 may be kept on. In this case, the joining force of the first and second surface fastener members 10, 20 turns to its ordinary joining force at the same time when they are joined, and the peeling resistance is increased at the time of separation. However, the level of the peeling noise generated at the time of peeling is maintained at 80 dB or less similarly.

FIG. 35 shows a modification of the fifth embodiment. According to this modification, a base material of a second surface fastener member 20 is constructed of a fiber material. A first linear material 39 including a magnetic linear material therein or mixed with magnetic powder is woven or knitted into the flat base material 21 at the same time when the flat base material 21 is woven or knitted so as to form a loop-like engaging element 22, and both ends of the linear material 38 are connected to the power supply 37. On the other hand, in a first surface fastener member 10 as well, a flat base material 11 is constituted of a fiber woven fabric or knitted fabric. When it is woven or knitted, a second linear material 40 mixed with a magnetic linear material or magnetic powder is woven or knitted with a loop formed. After the second liner material 40 is woven or knitted, part of the loop is cut so as to form a hook-like engaging element 12a. According to this modification also, when the power is turned on, lines of

magnetic force are generated, so that a joining force between the first and second surface fastener members 10, 20 is intensified, thereby suppressing the level of the peeling noise to 80 dB or less at the time of peeling.

FIGS. 36 to 39 show a sixth embodiment of the silent surface fastener 1 of the present invention using an adhesive agent as the auxiliary engaging and disengaging means, and its modification. According to the sixth embodiment shown in FIGS. 36 and 37 as well, a plurality of projections 34 are provided protrudedly in parallel in an area B in which no engaging elements are formed, of base materials 11, 21 composed of a fiber material of first and second surface fastener members 10, 20, like shown in FIG. 32. According to this embodiment, an adhesive agent layer 41 is formed by coating on the top face of the projection 34. The top face of the projection 34 is formed into an uneven face to increase the adhesive area between the adhesive agent layer 41 and the projection 34.

On the other hand, according to the modification of the sixth embodiment shown in FIGS. 38 and 39, a thick cloth portion 42 is formed along a non-formation area B between adjoining grid-like formation areas A of engaging elements 12, 22 formed in, for example, a ridge shape in base materials 11, 21 composed of a woven or knitted fabric of first and second surface fastener members 10, 20. This thick cloth portion 42 may be formed by using a bolder yarn as the warp (warp knitting yarn) to be

disposed in the thick cloth portion 42 than the other yarns, for example. According to this modification, a synthetic resin layer 43 is formed on the top face of the thick cloth portion 42 whose thickness is intensified, by means of molding or the like. Then, an adhesive agent layer 41 is formed on the surface of the synthetic resin layer 43 in the same manner as in the sixth embodiment.

Even when the adhesive agent is used as the auxiliary engaging and disengaging means of the present invention, the joining force of the first and second surface fastener members 10, 20 which is dropped by the noise suppressing means of the present invention can be compensated in the same manner as in the first to fifth embodiments. At the same time, when the first and second surface fastener members 10, 20 are peeled from each other, the both can be separated with an extremely small peeling noise without generation of any separation noise by the auxiliary engaging and disengaging means.

FIGS. 40 to 42 show a seventh embodiment of the silent surface fastener 1 which adopts an example of so-called mechanical engaging and disengaging means as the auxiliary engaging and disengaging means of the present invention. Male/female engaging and disengaging means 44 are formed in an engaging element non-formation areas B on the opposing surface of base materials of first and second surface fastener members 10, 20. The engaging and disengaging means 44 is formed of a

synthetic resin material and provided protrudedly on the surface of the base materials 11, 21 by adhesive bonding or welding (including molding). The height of the engaging and disengaging means 44 from the base material surface is set to a sufficient height for maintaining an engagement state of engaging elements 12a, 22a when the both are joined. As shown in FIGS. 40 and 42, the male/female engaging and disengaging means 44 comprises a plurality of male engaging and disengaging pieces 44a having a pyramid shape having a head, and a plurality of female engaging and disengaging portions 44b each having a concave shape in which the respective male engaging and disengaging pieces 44a are firmly fitted. As shown in FIG. 42, the respective adjoining female engaging and disengaging portions 44b are disposed in a matrix such that they are connected integrally.

When the first and second surface fastener members 10, 20 having such a structure are joined, the engaging elements 12a, 22a of the first and second surface fastener members 10, 20 engage each other while the respective male engaging and disengaging pieces 44a are fitted to the corresponding female engaging and disengaging portions 44b, as shown in FIG. 41. The male engaging and disengaging pieces 44a and the female engaging and disengaging portions 44b are not loosed easily due to friction force therebetween. For this reason, the male engaging and disengaging pieces 44a and the female engaging and

disengaging portions 44b are formed of a hard or soft synthetic resin foamed body as a composition material. If a magnetized powder material is mixed in ones of the male engaging and disengaging pieces 44a and the female engaging and disengaging pieces 44b while a magnetic powder is mixed in the others so as to use a magnetic force, an ordinary synthetic resin molded body having a smooth surface may be used instead of the foamed body.

The first and second surface fastener members 10, 20 of the seventh embodiment have a joining force capable of bearing a practical use like the first to sixth embodiments, and only a peeling noise of a small noise level suppressed by the noise suppressing means is generated at the time of peeling.

FIGS. 43 and 44 show an eighth embodiment of the silent surface fastener of the present invention using a vacuum absorption force which is another example of the mechanical auxiliary engaging and disengaging means. According to this embodiment, a plurality of sucking disks 45 are formed in an engaging element non-formation area B of a first surface fastener member 10, and a sucking plate piece 46 having a smooth surface, which the sucking discs 45 suck, is provided protrudedly in a corresponding engaging element non-formation area B of a second surface fastener member 20. The heights of the sucking disc 45 and sucking plate piece 46 from the surfaces of the flat base materials 11, 21 are set to the heights which

allow the first engaging elements 12a and the second engaging elements 22a to engage when the both suck each other.

With such a configuration, when the first and second surface fastener members 10, 20 join each other through a plane, the first engaging elements 12a and the second engaging elements 22a engage each other while the corresponding sucking discs 45 and sucking plate piece 46 suck through vacuum, thereby obtaining a required joining force. When the first surface fastener member 10 and the second surface fastener member 20 are separated from the joining state, the sucking discs 45 and the sucking plate piece 46 are separated from each other without generation of a noise, and only a noise by separation of the first and second engaging elements 12a, 22a employing the noise suppressing means is generated, whereby a noise level does not reach a level offensive to the ears.

FIGS. 45 to 47 show a ninth embodiment of the silent surface fastener 1 of the present invention which adopts a shape-memory function as the auxiliary engaging and disengaging means, and its modification. According to the ninth embodiment shown in FIGS. 45 and 46, male engaging elements 12a having an ordinary hook-like shape are formed at an element density of 35 pieces/cm^2 by weaving or knitting ordinary monofilaments into a base material surface of a fiber-made first surface fastener member 10. At the same time, a third engaging element 47 is formed by weaving or knitting

shape-memory linear materials.

Usable examples of the shape-memory linear material include a shape-memory alloy linear material such as Ti-Ni base alloy, Cu-Zn-Al base alloy, or Cu-Al-Ni base alloy, and a synthetic resin linear material such as polyurethane base, styrene-butadiene base, transpolyisoprene base, and polynorbornene base. When the metal linear material is used, preferably, the surface is coated with synthetic resin so as to secure durability and safety.

The third engaging element 47 composed of a shape-memory linear material is comprised of a pair of linear projections 47a whose tip ends are bent in an L shape in the direction of their contact as shown in FIG. 46, and the tip ends are set thermally in a contact state. When placed at an ambient temperature (not lower than temperature of transformation) upon usage, its shape is maintained. That is, the temperature of transformation is set in a range of the ambient temperature upon usage. On the other hand, when it is placed under an environment in which the ambient temperature is below the temperature of transformation, the linear projection 47a becomes more plastic so that it is easy to deform, and consequently, the tip ends separate easily as shown in FIG. 45.

On the other hand, the second surface fastener member 20 is subjected to no special processing except the above-described noise suppressing means is adopted, and only an

ordinary loop-like second engaging element 22a is formed on a surface of its flat base material 21. When it is intended to join the first surface fastener member 10 with the second surface fastener member 20, the ambient temperature is dropped to the temperature of transformation or lower. As a result, the plasticity of the third engaging element 47 is intensified, so that the tip ends of the pair of loop-like linear projections 47a are separated by a pressing force at the time of joining, and the loop-like engaging element 22a invades into between the pair of linear projections 47a through the gap. At this time, the ordinary hook-like engaging element 12a and the loop-like engaging element 22a engage each other.

If the ambient temperature is adjusted to a usage temperature of the silent surface fastener 1 which is the temperature of transformation or more in the joining state, the tip ends of the pair of linear projections 47a return to its original shape, that is, a shape which allows the tip ends to contact each other, and the hardness is intensified so as to form a complete loop shape. Thus, the engaging element 22a of the second surface fastener member 20 which invades into between the pair of linear projections 47a is blocked from being loosed easily, thereby securing the joining strength which may be dropped by the noise suppressing means.

To separate the first and second surface fastener members 10, 20 from each other, the temperatures of the surface fastener

members 10, 20 are lowered by cooling to the temperature of transformation or less. The plasticity of the third engaging element 47 is intensified by this cooling, so that the third engaging element 47 becomes easy to deform. Consequently, when a separation operation of the surface fastener 1 is performed, the loop-like engaging element 22a joined to the third engaging element 47 can be loosed easily without generation of a separation noise. Thus, when the separation operation of the silent surface fastener 1 is performed, it can be separated silently without generation of a peeling noise exceeding 80 dB which is reached by the noise suppressing means.

FIG. 47 shows a modification of the ninth embodiment. In this modification, a shape-memory linear material 49 is used as the hook-like engaging element 12a. As this shape-memory material 49, a shape-memory metal or synthetic resin is used in the same manner as in the above-described embodiments. The temperature of transformation is set to an environment temperature at the time of using the surface fastener in the same manner as in the above-described embodiments. If the temperature is below the temperature of transformation, the plasticity is intensified, so that the surface fastener becomes easy to deform as shown in FIG. 47A. If the temperature is over the temperature of transformation, the surface fastener returns to the original hook-like shape as shown in FIG. 47B, and at the same time, the hardness is intensified. Consequently, the

engagement force with the loop-like engaging element 22a is increased.

FIGS. 48 to 51 show a variety of modifications of the silent surface fastener 1 of the present invention which adopts the auxiliary engaging and disengaging means of the first to ninth embodiments by combining some of them. In these modifications, same reference numerals are also attached to substantially the same components. If explaining about each drawing briefly, a modification of FIG. 48 uses a magnetic force and an adhesive force at the same time as the auxiliary engaging and disengaging means. According to a modification shown in FIG. 49, a magnetic force and a fitting force are used in combination as the auxiliary engaging and disengaging means. A modification shown in FIG. 50 uses a magnetic force and a transformation force of a shape-memory material by combination. A modification shown in FIG. 51 uses a magnetic force, an adhesive force and a fitting force by combining these three components.